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APPLICATION NUMBER: 60/542,434

FILING DATE: *February 05, 2004*

RELATED PCT APPLICATION NUMBER: PCT/US04/41243



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Francene Sawyer

February 5, 2004

Francene Sawyer

Date

## U.S. Provisional Patent Application Entitled POWER MOSFET WITH DRAIN SENSE FUNCTION

### Inventor(s):

ZHENG SHEN, 438 Pine Brae Dr., Ann Arbor, MI 48105

DAVID OKADA, 5681 W Park Ave., Chandler, AZ 85226

**TITLE**

[0001] POWER MOSFET WITH DRAIN SENSE FUNCTION

**FIELD OF THE INVENTION**

[0002] This invention generally relates to power semiconductor devices.

**5 DESCRIPTION OF THE INVENTION**

[0003] The aspects, features and advantages of the present invention will become better understood with regard to the following description with reference to the accompanying drawings. What follows are preferred embodiments of the present invention. It should be apparent to those skilled in the art that the foregoing is illustrative only and not limiting, having been presented by way of example only. All the features disclosed in this description may be replaced by alternative features serving the same purpose, and equivalents or similar purpose, unless expressly stated otherwise. For instance, one skilled in the art can reverse the conductivity types shown in these embodiments as needed and without departing from the spirit or scope of the invention.

15 Likewise, implanted wells may be replace by doped epitaxial layers or other methods used which impart the same conductivity type without departing from the scope of the present invention. Therefore, numerous other embodiments of the modifications thereof are contemplated as falling within the scope of the present invention as defined herein and equivalents thereto. Use of absolute terms, such as "will not," "will," "shall," "shall not," "must," and "must not," are not meant to limit the present invention as the embodiments disclosed herein are merely exemplary.

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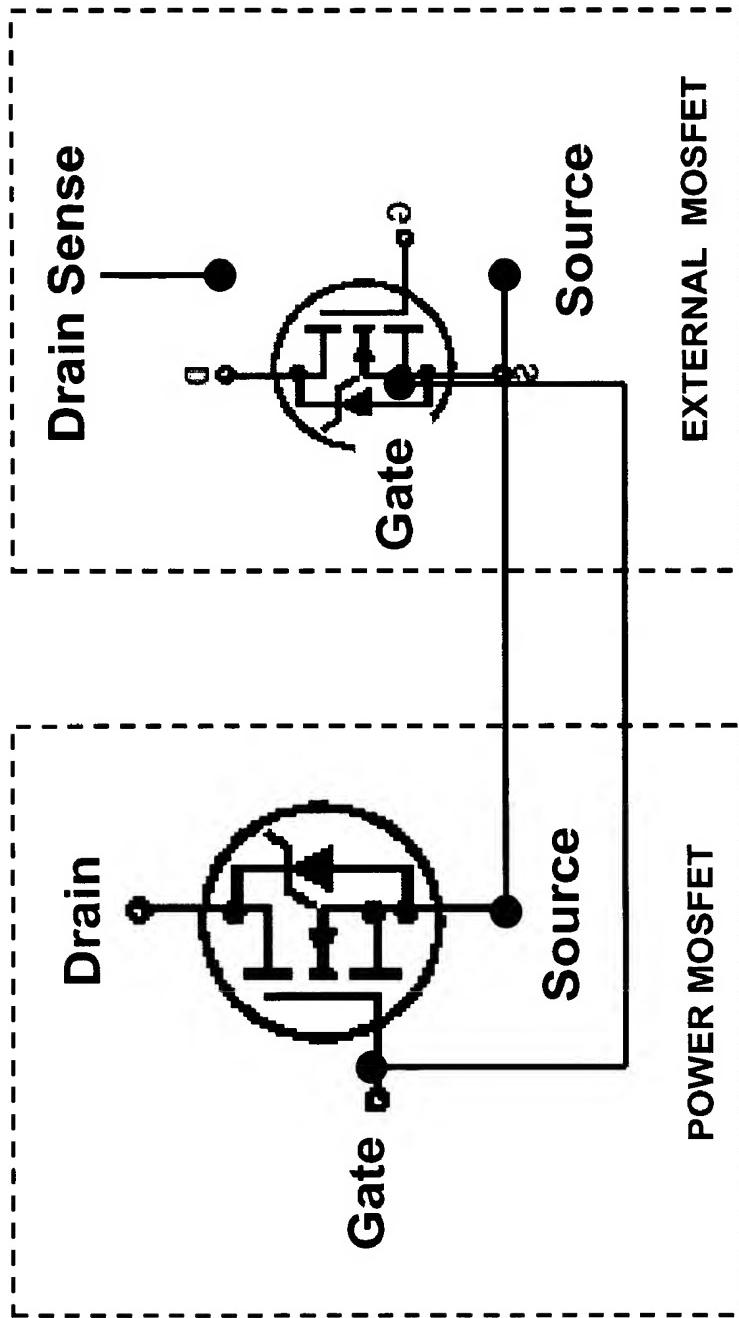
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## Discrete Power Mosfet With Integrated Drain Sense Function

1. Discrete power semiconductor device comprised of multiple transistors with common Source connection with one or more transistors having electrically isolated Drain and Gate connections
2. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having electrically isolated Drain connections
3. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having substantially different threshold voltages and electrically isolated Drain connections

## Motivation



### POWER MOSFET

### EXTERNAL MOSFET

Discrete Power MOSFETs are primarily used as high current switching elements. Monitoring the operating conditions of a discrete power MOSFET can be achieved by connecting the corresponding terminals of an external MOSFET to the power MOSFET's Gate and Source terminals. Circuitry connected to the Drain Sense terminal can provide input information to the control circuit to provide circuit protection and performance optimization.

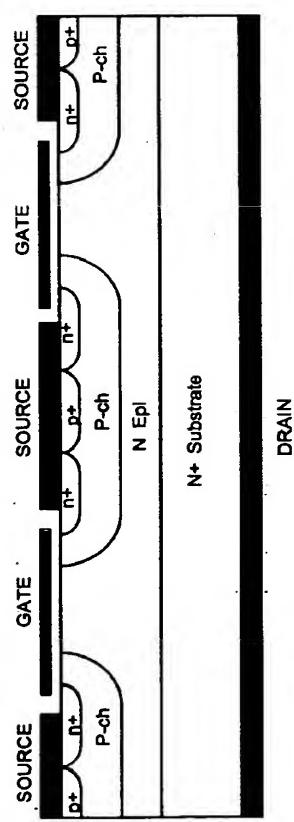
## Motivation

It is advantages to monolithically integrate the sensing transistor with the power MOSFET

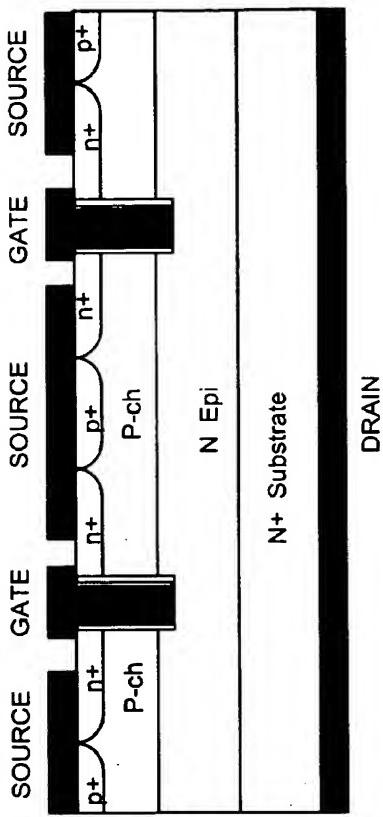
- 1) Eliminates the need for the external MOSFET
- 2) Improved parametric matching of both the power and sense transistor
- 3) The power and sense transistor's relative sizes can be accurately established. This allows the sense and power transistor's area dependent parameters to be accurately ratioed.
- 4) The monolithic integration of both the power and sense transistors feature excellent temperature tracking for improved matching and accuracy.
- 5) The threshold voltages of the power and sense transistor can be adjusted independently for use in applications where this would be advantageous.

## Conventional Power MOSFET Structures

VERTICAL PLANAR POWER MOSFET



TRENCH POWER MOSFET

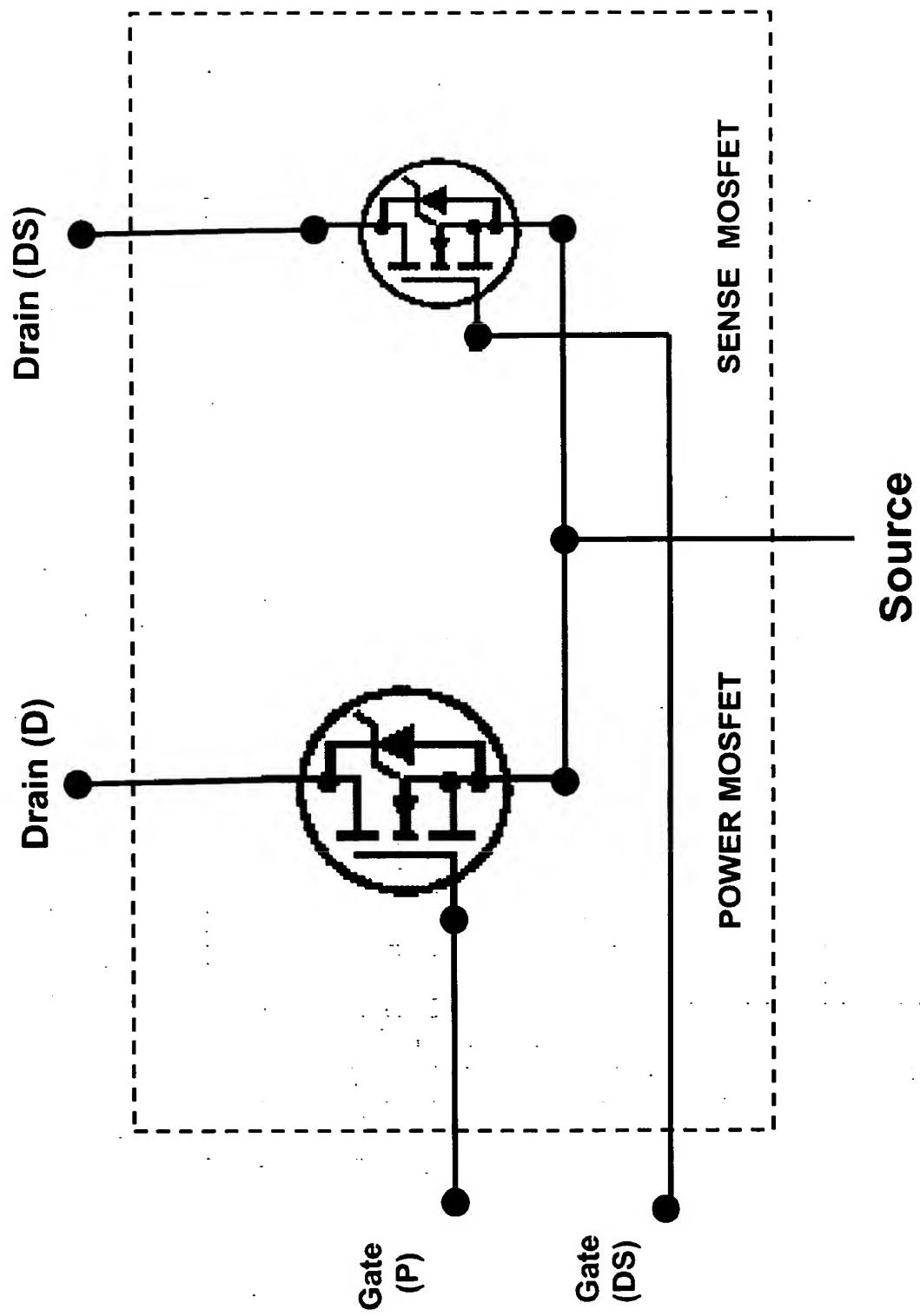


Conventional power MOSFET structures have a common backside Drain contact. It would be very complicated and expensive to monolithically integrate a isolated Drain sense feature into these structures.

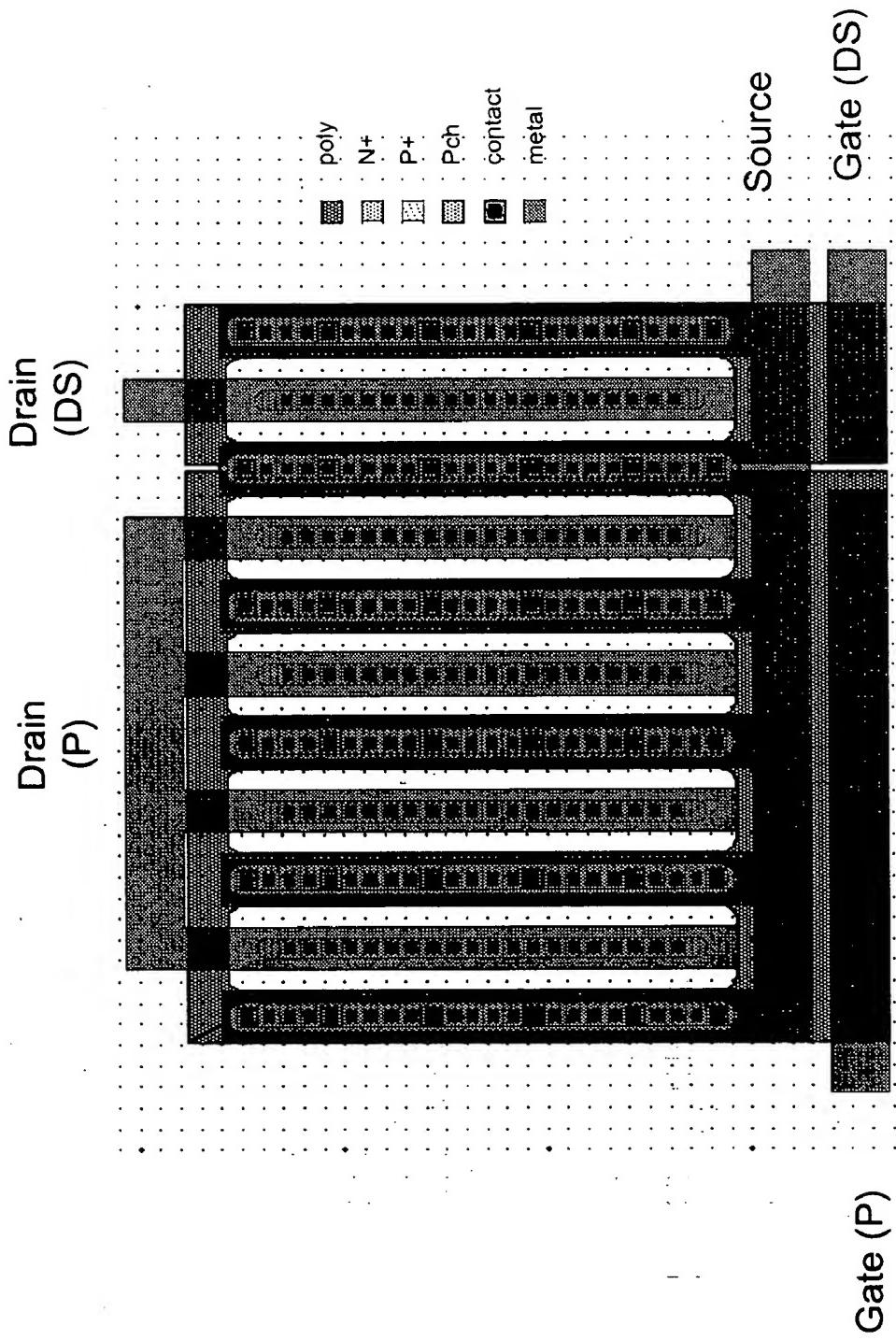
## Discrete Power Mosfet With Integrated Drain Sense Function

We have invented a discrete power MOSFET with integrated drain sense functionality by building the discrete power MOSFET using a lateral power MOSFET technology.

1. Discrete power semiconductor device comprised of multiple transistors with common Source connection with one or more transistors having electrically isolated Drain and Gate connections

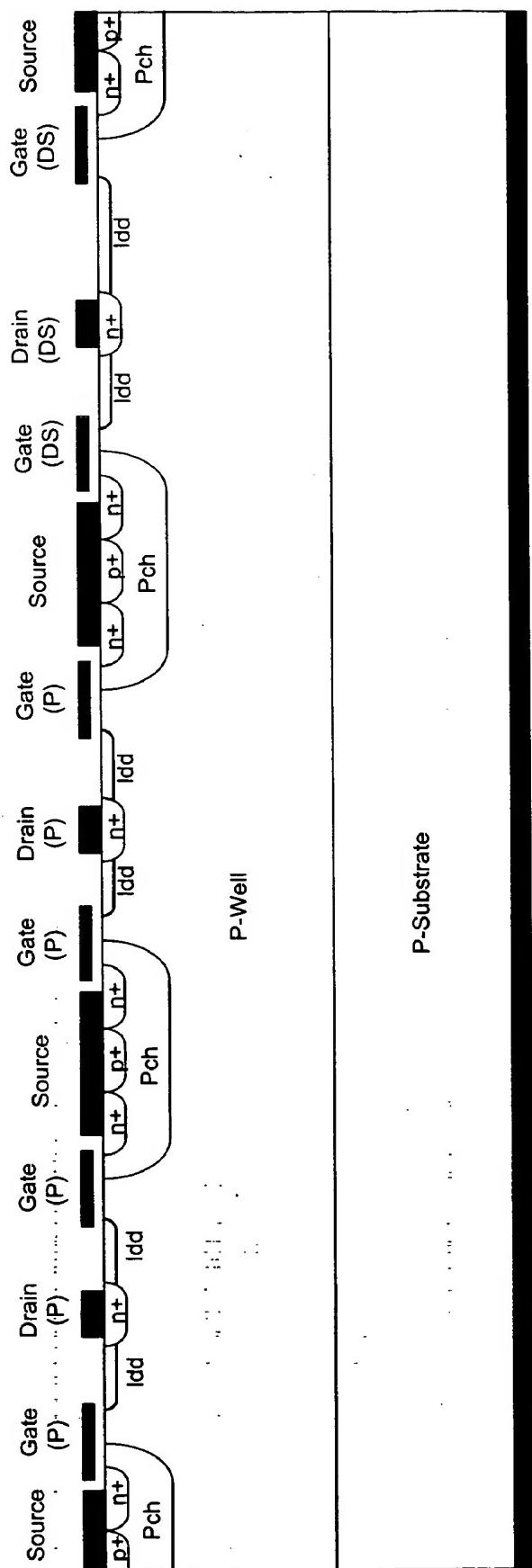


1. Discrete power semiconductor device comprised of multiple transistors with common Source connection with one or more transistors having electrically isolated Drain and Gate connections



Device Layout Showing Drain Sense Design

1. Discrete power semiconductor device comprised of multiple transistors with common Source connection with one or more transistors having electrically isolated Drain and Gate connections

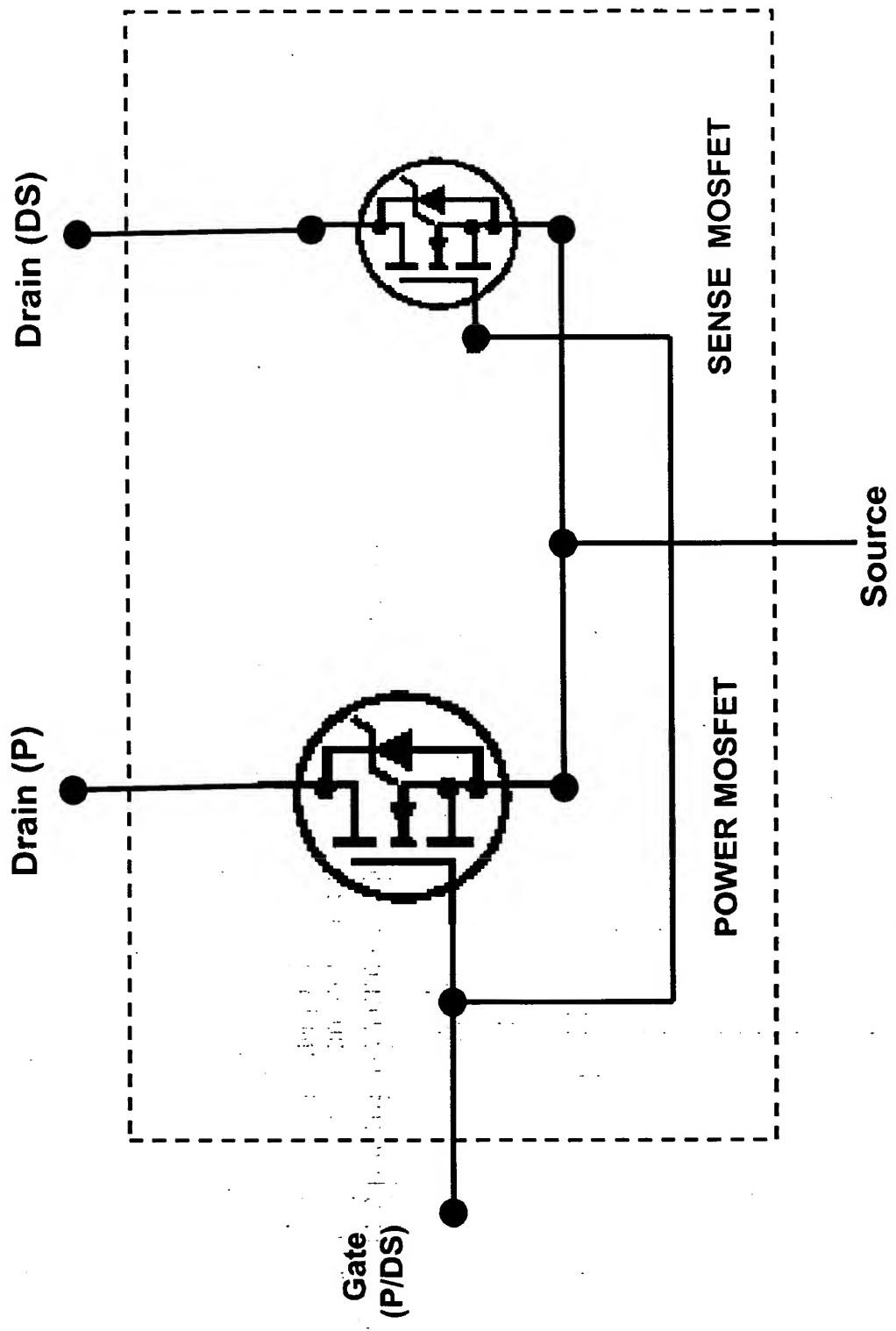


**Cross-Sectional Diagram of a Power MOSFET With Integrated Drain Sense**

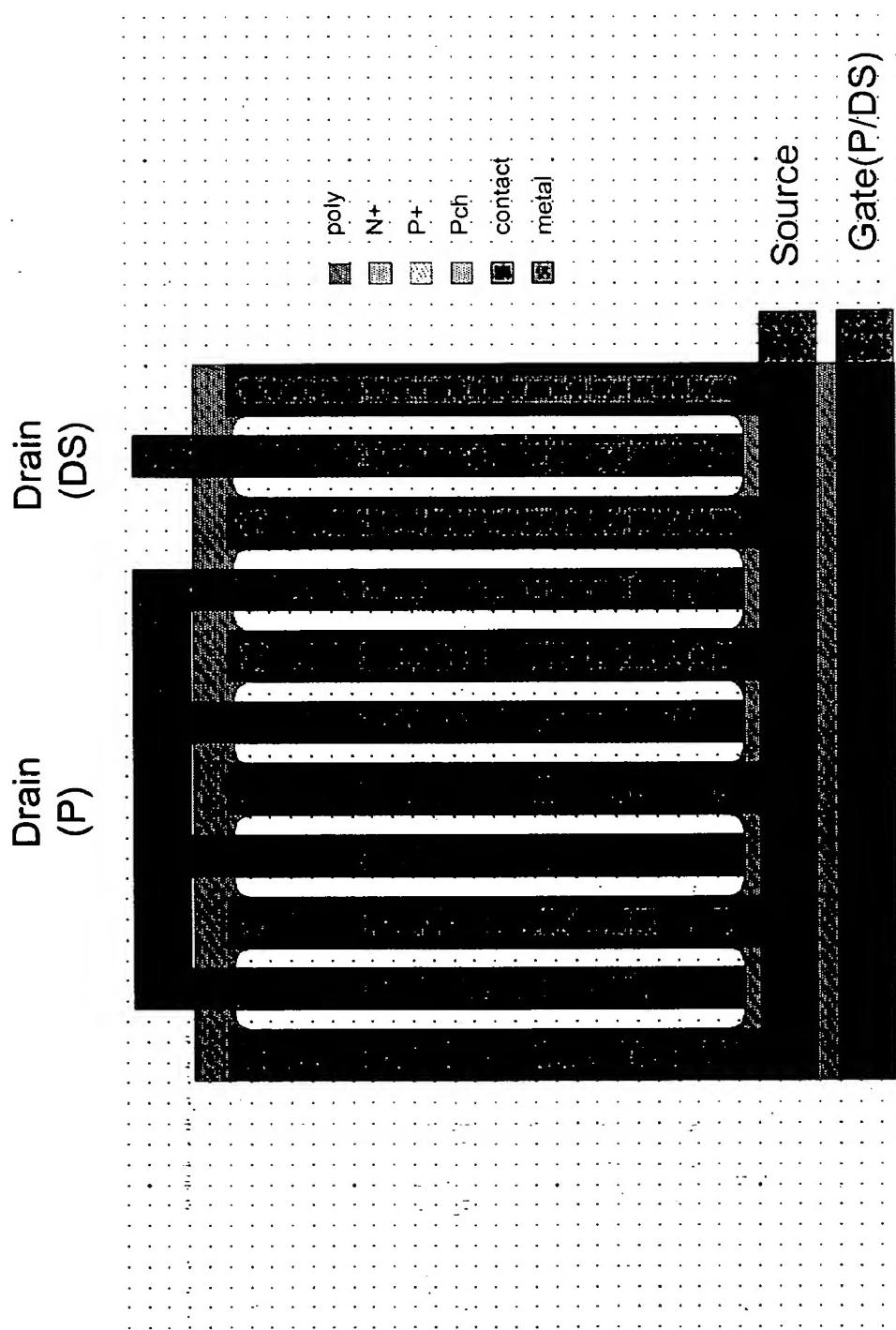
(P) Indicates Power MOSFET Terminal

(DS) Indicates Drain Sense MOSFET Terminal

2. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having electrically isolated Drain connections

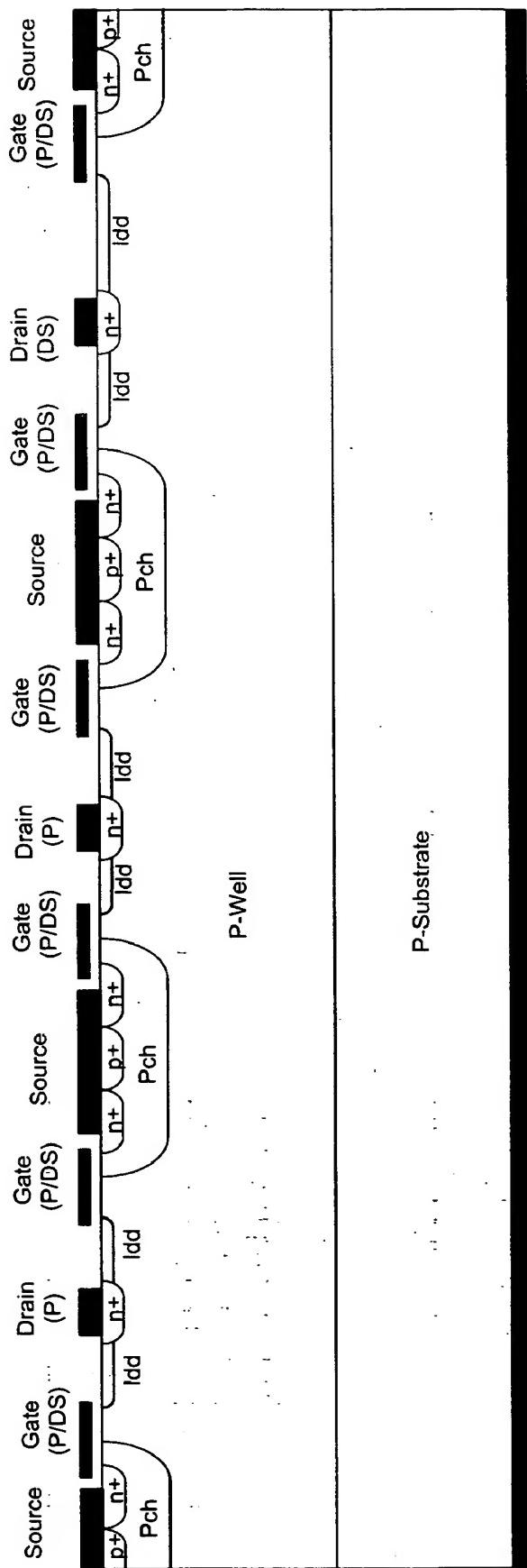


2. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having electrically isolated Drain connections



Device Layout Showing Drain Sense Design

**2. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having electrically isolated Drain connections**

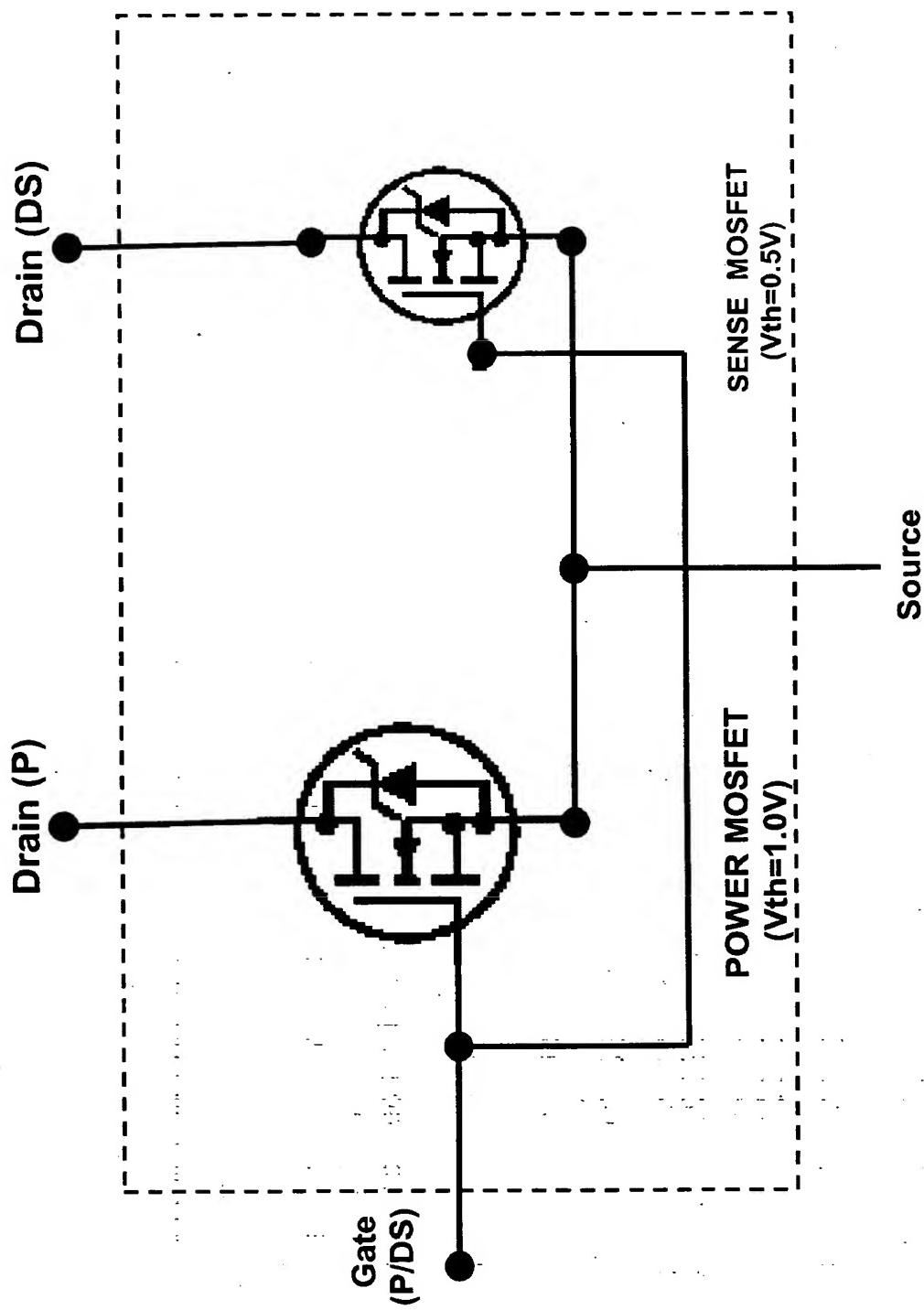


**Cross-Sectional Diagram of a Power MOSFET With Integrated Drain Sense**

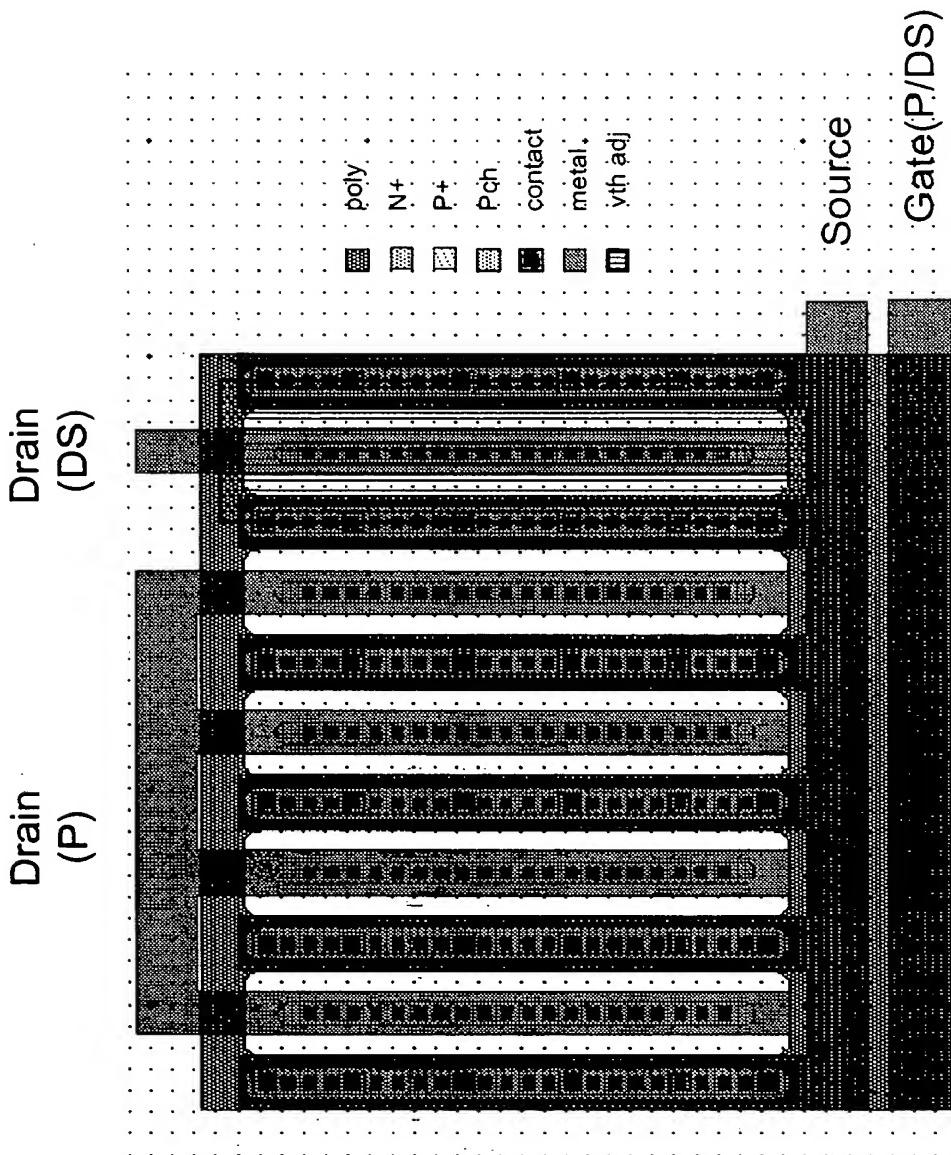
(P) Indicates Power MOSFET Terminal

(DS) Indicates Drain Sense MOSFET Terminal

3. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having substantially different threshold voltages and electrically isolated Drain connections

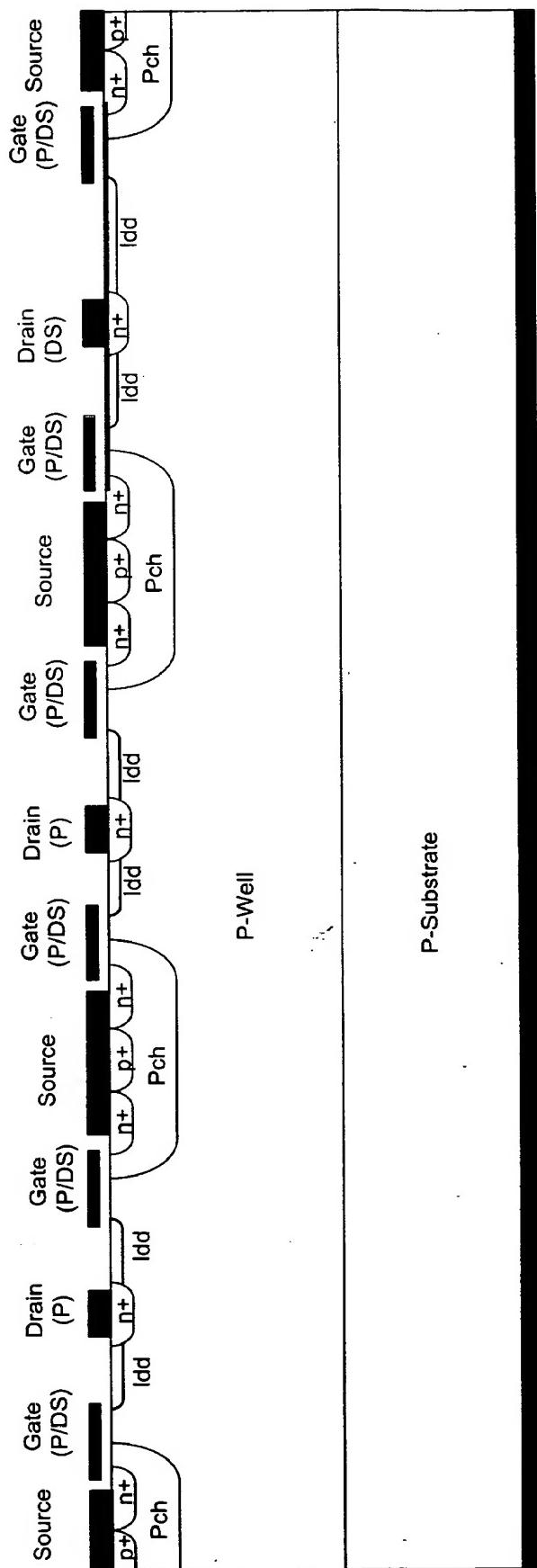


3. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having substantially different threshold voltages and electrically isolated Drain connections



Device Layout Showing Drain Sense Design

3. Discrete power semiconductor device comprised of multiple transistors with common Source and Gate connections with one or more transistors having substantially different threshold voltages and electrically isolated Drain connections



**Cross-Sectional Diagram of a Power MOSFET With Integrated Drain Sense**

(P) Indicates Power MOSFET Terminal

(DS) Indicates Drain Sense MOSFET Terminal

— Indicates Threshold Adjust Implant

PTO/SB/16 (05-03)  
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This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EL 753209191 US

16085 U.S.PTO  
60/542434  
02/05/2004

**INVENTOR(S)**

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Zhang	Shen	Ann Arbor, MI

Additional inventors are being named on the 1 separately numbered sheets attached hereto

**TITLE OF THE INVENTION (500 characters max)**

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

Customer Number: 24964

OR

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**ENCLOSED APPLICATION PARTS (check all that apply)**

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|--|--|
| <input checked="" type="checkbox"/> Specification Number of Pages <u>2</u> | <input type="checkbox"/> CD(s) Number _____    |
| <input checked="" type="checkbox"/> Drawing(s) Number of Sheets <u>14</u>  | <input type="checkbox"/> Other (specify) _____ |
| <input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76           |  |

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

No.

Yes, the name of the U.S. Government agency and the Government contract number are: \_\_\_\_\_

Respectfully submitted,

[Page 1 of 2]

Date February 5, 2004

SIGNATURE William C. Hyung  
TYPED or PRINTED NAME William C. Hyung

REGISTRATION NO. 36,169

(if appropriate) Docket Number: 104023-678-PRO

TELEPHONE (212) 813-8815

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Docket Number 104023-678-PRO

INVENTOR(S)/APPLICANT(S)		
Given Name (first and middle [if any])	Family or Surname	Residence (City and either State or Foreign Country)
David	Okada	Chandler, AZ

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LIBNY/4278490.1

Country: US  
Application No.: TBA  
Filing Date: February 5, 2004  
Inventors: Zheng Shen and David Okada  
Title: POWER MOSFET WITH DRAIN SENSE FUNCTION  
Atty Docket No.: 104023-678-PRO

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Deposited: February 5, 2004

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Submitted herewith are the following items:

1. Provisional Application For Patent Cover Sheet (in duplicate) ( 4 pages);
2. Provisional Application of Zheng Shen and David Okada (16 pages);
3. This Certificate of Express Mailing bearing Express Mailing Label No. and deposit date stated above (1 page); and
4. Return Receipt Postcard.

TOTAL PAGES IN THIS SUBMISSION: 21 + postcard

Francene Sawyer  
Francene Sawyer